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Research Article

Correlation Between Retinal Ganglion Cell Complex Parameters and Retinal Nerve Fiber Layer Thickness in Early Glaucoma

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Received: January 07, 2017; **Published:** February 07, 2017

Abstract

Purpose: To correlate between the average GCC parameters and average RNFL thickness in early glaucomatous eyes.

Patients and Methods: Seventy five eyes of 60 patients whom ages ranged from 35 - 50 years were subjected to full ophthalmological examination and accordingly the patients were divided into 2 groups: Group (1) included 30 patients of normal control and Group (2) included 45 patients of early glaucoma.

Results: Group (A) showed that Mean RNFL thickness and ganglion cell parameters complex values were correlated to each others with normal parameters in normal eyes.

Group (B) showed that Mean RNFL thickness and mean ganglion cell complex parameters were affected and correlated to each others with early affection of ganglion cell layer thickness and parameters than nerve fiber layer thickness in early glaucomatous eyes.

Conclusion: Mean ganglion cell complex including thickness and parameters were affected earlier and more profound than RNFL thickness in patients with early glaucoma.

Keywords: *GCC Parameters; RNFL; OCT; Early Glaucoma*

Abbreviations

RGCC: Retinal Ganglion Cell Complex; RNFL: Retinal Nerve Fiber Layer; OCT: Optical Coherent Tomography; SD: Spectral Domain; IPL: Inner Plexiform Layer; FLV: Focal Loss Volume; GLV: Global Loss Volume; ONH: Optic Nerve Head

Introduction

Although glaucoma is classified as an optic nerve disease, pathologically it is characterized by the death of retinal ganglion cells (RGCs) and their axons. Traditionally, loss of RGCs has been judged based on damage to the optic nerve head (ONH) and visual field (VF) defects. Because these assessments do not exactly reflect the extent to which the RGC population is affected, it became evident that any method enabling measurement of RGCs would advance both early detection and longitudinal monitoring of glaucoma [1].

Advances in ocular imaging as high resolution optical coherence tomography (OCT), have enabled assessment of RGC axons by measuring the thickness of the peripapillary retinal nerve fiber layer (RNFL) in addition to the GCC in macular area [2]. Decreases in macular thickness that are believed to be due to loss of RGCs and also correlate with RNFL thickness loss have been reported in early glaucomatous eyes [3].

Glaucoma preferentially affects the ganglion cell complex (GCC), which is the sum of the three innermost layers:

1. The RNFL, which is composed of axons of GCL.
2. The ganglion cell layer (GCL), which is composed of cell bodies.
3. Inner plexiform layer (IPL), which contains the RGC dendrites [4].

A few recent studies have shown that measurement of macular GCC thickness has the same glaucoma diagnostic performance as RNFL thickness; however, it is possible that including the RNFL in the measurement may affect the diagnostic ability of GCC thickness [5]. Other studies showed that loss of macular thickness in glaucoma can be attributed mainly to RGC and secondary NFL atrophy. It may be useful, therefore, to assess macular GCC parameters, because they concluded that macular GC loss may result in significant thinning and they proposed quantitative detection of glaucomatous damage at the posterior pole by decreasing the thickness of ganglion cells [6].

Patients and Methods

Seventy five eyes were included in this study with mean age 45+/-10 years -divided into 2 groups:
Group (1) included 30 eyes of normal eyes whom the control.

The control group participants had the following inclusion criteria:
* The intraocular pressure (IOP) less than 21 mm Hg by applanation tonometry for both eyes and C/D ratio not exceed 0.4 with bilateral symmetrical discs.
*The central corneal thickness ≥ 500 μm.
* No history of chronic ocular or systemic corticosteroid use.

Group (2) include 45 eyes of patients whom diagnosed as early glaucoma (POAG) with the following inclusion criteria:
*The IOP never exceeds 26 mmHg by applanation tonometry.
*C/D ratio less than 0.6
* No central visual field changes
* Best corrected visual acuity not less 20/40.
* Early optic nerve head (ONH) glaucomatous changes such as diffuse or localized rim thinning, disc (splinter) hemorrhage, vertical cup/disc ratio difference between two eyes < 0.2, or rim notching detected on baseline dilated fundus examination and confirmed by stereo disc photographs.

All patients had complete ophthalmic examination, including slit lamp biomicroscopy (for optic nerve head evaluation) gonioscopy, tonometry and Informed consent was obtained from all participants.

Exclusion criteria:

- High refractive error > +3.00D or < −7.00 D
- Other optic disc abnormalities
- Lens opacity or previous intraocular surgery
- Diabetic retinopathy, age related macular degeneration, cystoid macular edema.
- History of other ocular and systemic diseases

Methodology

- Prior to OCT we put 1% of medriacyle and the mean average thickness in all quadrants obtained by OCT RNFL thickness strategy.
- Optical coherence tomography optovue with fast RNFL thickness (3.4) scan around the ONH. The graph is generated from a 3.45 mm diameter circle that is always centered on the ONH as time Domain OCT scan speed is 26,000 A scans/sec.

- Values for RNFL thickness are compared to age appropriate normative data base and indicates whether they fall within the top 5% (coded white) top 95% (green) bottom 5% (yellow) or bottom 1 % (red).
- ONH and 3D disc scan protocol also obtained to asses C/D ratio and also RNFL thickness for all patients. A 3-D scan of the optic disc is captured and the software automatically delineates the optic disc margin.
- Ganglion cell layer scan protocol was finally done The ganglion cell complex (GCC) scan pattern consists of 15 vertical and 1 horizontal scan lines shown overlaid on a red-free fundus photograph.

The scans for RNFL and GCC are compared to age appropriate normative data base and any loss graded whether they fall within the (green) or (yellow) or (red).

The printed out test analyzing bilateral GCCl which including also NFLT and optic nerve head analysis.

All the data in normal and early glaucoma included

- Average RNFL thickness, average GCL thickness, global loss volume (GLV) which is the integration of all negative deviation values normalized by the overall map area, and focal loss volume (FLV) which is the integration of negative deviation values in the areas of significant focal loss Figure 1.

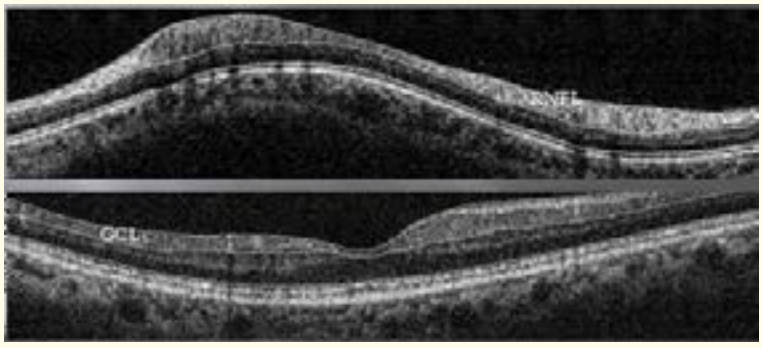

Figure 1: *RNFL and GCL measuring by OCT.*

Finally comparative study between the mean average thickness of RNFL in early glaucoma and control and the mean average thickness of GC layer in early glaucoma and control Figure (2-3) and results were obtained and statistical analysis were done by T test with P value significant when it is below 0.05.

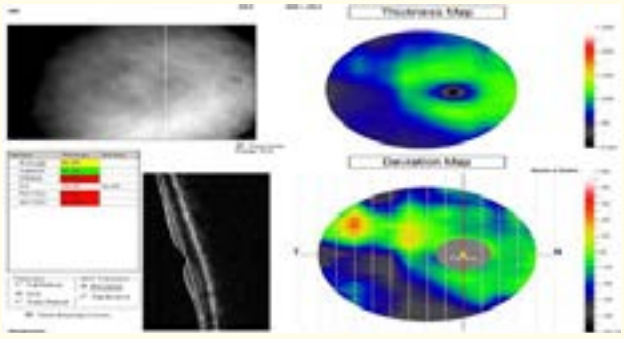

Figure 2: *Measuring GCC thickness.*

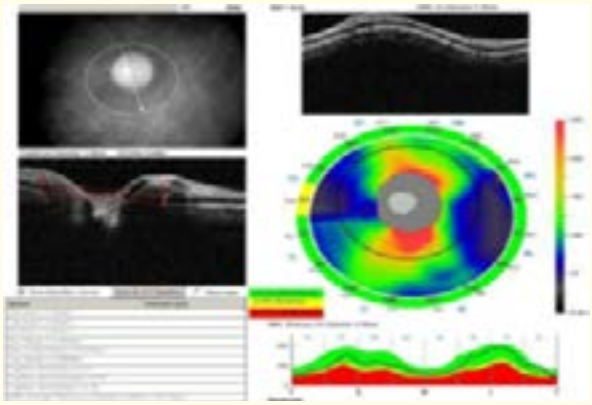

Figure 3: *Measuring of RNFL thickness.*

Results

Our study results showed that according to Glaucoma Staging patients with early glaucoma with mean C/D ratio 0.507 showed that the mean average ganglion cell thickness is more sensitive and early reduced in early glaucoma than average RNFL thickness Figure (4-5).

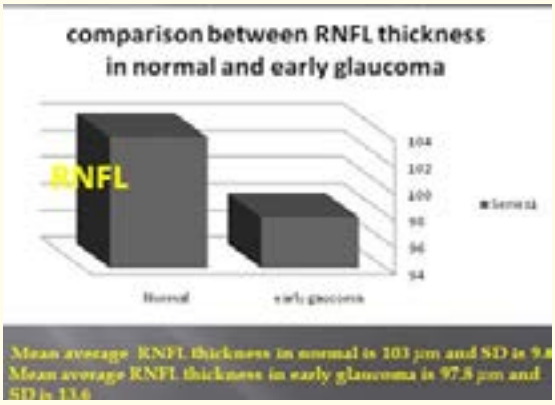

Figure 4: *Comparison between average RNFL thickness in normal and early glaucoma.*

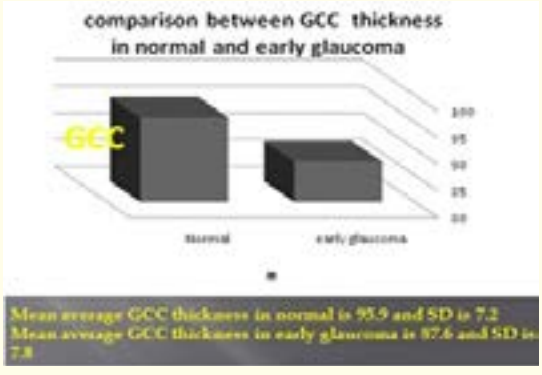

Figure 5: *Comparison between average GCL thickness between normal and early glaucoma.*

Not only the average ganglion cell thickness showed significant differences compared to normal eyes and also early affected than average RNFL in early glaucoma but also both focal loss volume (FLV) and global loss volume (GLV) parameters were found to be affected earlier in early glaucomatous eyes Figure (6-7).

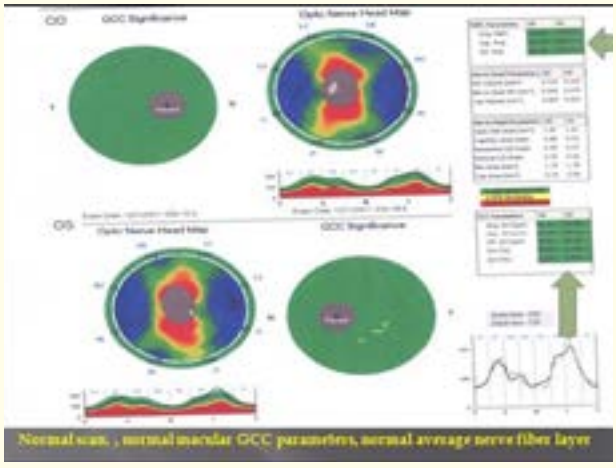

Figure 6: *Showed normal average NFL thickness and normal average GCL thickness in group (1).*

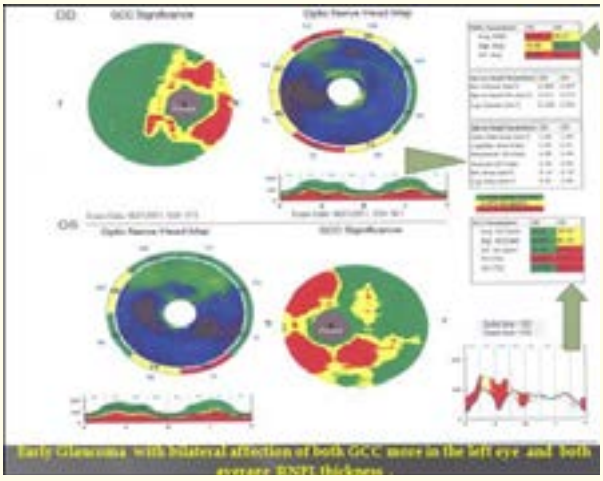

Figure 7: *Bilateral affection of both average RNFL and GCL thickness with affected FLV in the right eye and both FLV and GLV in the left eye in group (2).*

We found that FLV and GLV had higher diagnostic accuracy than the simple diagnosis through average decrease in GCL thickness with or without decreases in average RNFL thickness, where The GLV and FLV parameters sum up the volume of GCC loss in the macula with differing levels of focality.

The comparison between mean average GCL thickness in patients with early glaucoma (87.6 microns) SD (+/-7.8) and normal patients (95.9 microns) SD (+/-7.2) showed significant decrease than the comparison between mean average RNFL thickness in early glaucoma (97.8 microns) SD (+/-13.6) and normal patents (103.1 microns) SD (+/-9.6) where the p value 0.032 in the first comparison is higher and more significant than p value 0.025 in The second comparison.

Also GCC parameter as global loss volume, and focal loss volume showed early affection in most cases that showed decrease in mean average GCL thickness than normal however in our study it did not specifically show early affection of the FLV before GLV.

However some cases showed early affection of the FLV and other showed early affection of GLV and other cases showed both affection of both FLV and GLV with decrease in mean average of GCL thickness in early glaucoma.

But in conclusion for the results regarding FLV and GLV we found that in almost all cases in early glaucoma showed affection of GCC the global loss volume was always higher in value than focal loss volume.

Discussion

Since a significant loss of GCC can occur prior to detectable visual field deficits and that structural loss can precede detectable function loss by up to 5 years, so developing methods to quantify GCC-related glaucomatous changes could lead to glaucoma detection at an earlier stage and more accurate tracking of glaucoma progression.

Glaucoma predominantly causes thinning of the nerve fiber layer, ganglion cell and inner plexiform layers. The GCC scan provides new parameters for glaucoma diagnosis that improved by concentrating on the ganglion cell complex rather than the RNFL thickness only [7].

Through the use of high-resolution image technique optical coherence tomography (OCT) that allows high-resolution [8], we are able to evaluate and quantify macular GCC and peripapillary NFL thickness and to analyze the effect of glaucoma in these areas due to the ability of macular GCC parameters to discriminate normal eyes and eyes with early glaucoma that is higher and earlier comparable to that of the peripapillary RNFL which is not as previous literatures [9].

In this study not only the average ganglion cell thickness (GCC) showed significant decrease than average RNFL in early glaucoma compared to normal but also both of focal loss volume (FLV) and global loss volume (GLV) considered as GCC parameters were found to be affected earlier in early glaucomatous eyes with higher diagnostic accuracy as GLV and FLV parameters [10].

Moving forward, it is hoped that the available -OCT instruments equipped with a broadband light source can provide improved contrast and resolution of outer retinal layers and capabilities to separate the GCL and the IPL for better evaluation of changes to individual layers in glaucoma. Also the GCC map that is could be correlated with VF defects point-by-point. When they correspond, one may be more confident that the defects are real rather than artifacts. It is important to note that each millimeter on the retina corresponds to about 3.5° on the VF [11].

After Zeimer., *et al.* suggested the importance of macular thickness measurements in evaluation of glaucomatous damage [12], several studies were performed to determine the effectiveness of such a thickness assessment for glaucoma detection.

These studies showed that macular thickness measurements were able to detect glaucomatous damage [13]. However other studies performed suggesting that the measurements had no better predictive value than RNFL thickness assessment and the reason may be that total macular thickness was assessed, rather than that of the RGC layer, thus decreasing the specificity of macular thickness for glaucoma diagnosis [14].

Conclusion

Mean RNFL thickness and ganglion cell thickness and parameters were decreased in early glaucoma with early affection of ganglion cell layer thickness and its parameters than nerve fiber layer thickness in early glaucomatous eyes.

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Volume 5 Issue 2 February 2017